EUB Alberta Energy and Utilities Board

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Directive 020

Revised edition July 24, 2007

Well Abandonment Guide

The Alberta Energy and Utilities Board (EUB/Board) has approved this directive on July 24, 2007.

B. T. McManus, Q.C.
Acting Chairman

Contents

1 Introduction 1
1.1 What's New in This Edition 1
1.2 Overview 1

2 Well Abandonment Process 3
Step 1: Identify the Type of Well Abandonment 3
Step 2: Determine if Planned Operation Is Routine or Nonroutine 3
Step 3: Request EUB Approval for Nonroutine Abandonment Operations 3
Step 4: Perform Required Testing Before Surface Abandonment 3
Step 5: Report Completed Surface Abandonment 4
Step 6: Complete Additional Reporting Requirements 4

3 Audit and Enforcement Process 4

4 Open-Hole Abandonment Requirements 5
4.1 Oil Sands Evaluation Wells and Test Hole Wells 7
4.2 Wells in Program Area 1 (Western Alberta) 8
4.3 Wells in Program Area 2 (Northeastern Alberta) 10
4.3.1 Prescribed Plugging Program for Non-Oil Sands Wells 13
4.3.2 Prescribed Plugging Program for Oil Sands Wells 13
4.4 Wells in Program Area 3 (East Central Alberta) 14
4.4.1 Prescribed Plugging Program 16
4.5 Wells in Program Area 4 (Southeastern Alberta) 17
4.5.1 Prescribed Plugging Program 17
4.5.2 Inspection Requirements for Wells in Program Area 4 21
4.6 Surface Abandonment 21
4.6.1 Testing 21
4.6.2 Cutting and Capping 22

5 Cased-Hole Abandonment Requirements 24

5.1 Wells Not Penetrating Oil Sands Zones 24
5.1.1 Noncompleted Wells 24
5.1.2 Wells with a Cemented Liner 24
5.1.3 Wells with an Uncemented Liner 24
5.1.4 Zonal Abandonment within a Completed Well 24
5.1.5 Completed Horizontal Wells in a Single Formation 25
5.1.6 Completed Horizontal Wells across Multiple Formations 26
5.2 Wells Penetrating Oil Sands Zones 26
5.2.1 Noncompleted Wells 26
5.2.2 Completed Wells 26
5.3 Groundwater Protection 27
5.3.1 Remedial Cementing 27
5.3.2 Removing Casing and Setting a Cement Plug 28
5.4 Surface Abandonment 29
5.4.1 Testing 29
5.4.2 Cutting and Capping 29

Appendix 1 Confirming the Location of Cement Plugs 33
Method 1–Confirmation of Plug Location with Drill Pipe 33
Method 2–Direct Density Plug Logging 33
Method 3–Hydrostatic Pressure Plug Logging 33
Method 4–Radioactive Tracer Logging 34
Plug Log Submission Requirements 34

Appendix 2 Testing for Surface Casing Vent Flow and Gas Migration 36
Surface Casing Vent Flow Testing 36
Gas Migration Testing 37

Appendix 3 Requesting a Groundwater Protection Waiver 39
Situation 1–Absence of Porosity Above Cement Top 39
Situation 2–Failure of Remedial Cementing in the Area 39
Situation 3–Absence of Deleterious Crossflow 40

Figures

1. Area boundaries for all program areas 6
2. Unacceptable plugs 7
3. Area boundary for Program Area 1 9
4. Plug placement examples for Program Area 1 11
5. Area boundary for Program Area 2 12
6. Prescribed plugging program for Program Area 2 14
7. Area boundary for Program Area 3 15
8. Prescribed plugging program for Program Area 3 16
9. Area boundary for Program Area 4 18
10. Prescribed plugging program for Program Area 4 19
11. Options for isolating the White Specs Formation 20
12. Gas migration required test area 23
13. Gas migration required test area 30
14. Typical cased-hole abandonment schematic 31

1 Introduction

1.1 What's New in This Edition

Updates in this edition of the directive cite compliance information in *Directive 019: EUB Compliance Assurance—Enforcement*, with references to the matrix of risk items on the EUB Web site where applicable. References to other EUB published documents have also been updated as required.

1.2 Overview

Sections 3.010 (7) and 3.068 (2) of the *Oil and Gas Conservation Regulations* require the licensee to conduct abandonment, casing removal, zonal abandonments, and plug backs in accordance with the current edition of *Directive 020: Well Abandonment Guide*.

When planning to abandon a well, a licensee has to determine whether the planned abandonment operation will be routine or nonroutine, as defined by this directive. A planned abandonment operation is *routine* if it meets all the requirements that apply to the well based on

- the type of well being abandoned,
- the well's geographic location,
- the impact of the well on any oil sands zones, and
- the absence of a wellbore problem.

Routine abandonment operations ***do not*** require EUB approval before work is started.
Nonroutine abandonment operations ***do*** require EUB approval before work is started.

Some examples of *nonroutine* abandonment operations are

- the planned abandonment of a well that has a wellbore problem,[1] which includes
  - a fish-in-the-hole across two or more porous zones,
  - a leaking plug, or
  - a ghost hole across two or more porous zones;
- a reabandonment of a well;
- a planned surface abandonment of a well with pressure remaining at surface;
- a planned surface abandonment of a well where cement does not cover all nonsaline groundwater zones;
- the planned use of cement plugs in a well in a manner that does not meet the requirements stated in this directive;
- the planned use of a bridge plug inside the surface casing;
- the planned use of any type of plugging device that will be set more than 15 metres (m) above the completion interval; and
- the planned removal of uncemented casing from the well in a manner that does not meet the requirements stated in this directive.

An electronic data capture system for *Digital Data Submission* (DDS) is in place for licensees to submit nonroutine well licence abandonment requests and well abandonment notifications.

[1] Wells with casing failures, surface casing vent flows, or gas migration must be reported via the EUB's Digital Data Submission (DDS) Casing Failure service or the DDS Surface Casing Vent Flow/Gas Migration service, as required by *Interim Directive (ID) 2003-01*. All wellbore problems (including casing failures, surface casing vent flows, and gas migration) must be eliminated prior to proceeding with well abandonment.

This directive may not address every abandonment situation encountered in Alberta. If the licensee has questions about a planned abandonment operation, contact the EUB Well Operations Section at (403) 297-5290 *before* beginning any work. If an emergency situation occurs after hours or on a weekend, contact the appropriate EUB Field Centre.

Abandonment requirements include:

1) A licensee must review the existing cement behind the casing string(s) of the well before beginning abandonment operations, and if hydraulic isolation does not exist between porous zones, the licensee may be required to perform remedial downhole work before the final abandonment of the well in order to establish isolation between porous zones. This change is to ensure that the wellbore is returned to its original state of isolation between zones of different fluids and pressures for the future integrity of the well (Section 5, second paragraph).

2) *All* nonsaline groundwater must be covered with cement, rather than just the base of the nonsaline groundwater. Alberta Environment defines nonsaline groundwater as any strata containing water with a total dissolved solids content less than 4000 milligrams per litre. This change is to ensure the long-term protection and preservation of groundwater and to prevent the possibility of crossflow between different water sands with varying salinities (Section 4, third paragraph, and Section 5.3).

3) A licensee must weld a steel plate across the surface casing in a surface abandonment of an open-hole well. Previously, the surface casing could be sealed with either cement slurry on top of a wiper plug *or* a steel plate welded across the surface casing. This change is to provide a more competent seal at surface and to reduce the risk of leaks (Section 4.6.2).

4) The metal cap welded to the surface casing must be metallurgically compatible to the casing and welded according to Industry standards to eliminate the possibility of creating corrosive cells that may occur when dissimilar materials are used (Sections 4.6.2 and 5.4.2).

5) Surface equipment, cement pads, debris and produced liquids associated with the well licence must be removed within 12 months of the cutting and capping operation. Record of the removal and cleanup activities must be retained and may be requested in an audit (Sections 4.6 and 5.4).

Five other requirements that are in effect are:

1) the requirements for abandoning oil sands evaluation and test hole wells (Section 4.1);

2) the requirements for abandoning a cased-hole well completed with a cemented liner (Section 5.1.2);

3) the requirements for abandoning a cased-hole well completed with an uncemented liner (Section 5.1.3);

4) the requirement to allow Hydromite cement to be used instead of class "G" cement when abandoning a completed cased-hole well (that does not penetrate an oil sands zone) with a bridge plug or with a plug in a permanent packer (Section 5.1.4) (this requirement was originally defined in *Interim Directive [ID] 91-1: Abandon-A-Zone/Temporary Abandon-A-Zone ERCB Approval Requirement Change*; *ID 91-1* is hereby rescinded); and

5) the requirements for abandoning a single-zone horizontal cased-hole well (Section 5.1.5).

2 Well Abandonment Process

The objective of a well abandonment is to cover all nonsaline groundwater and to isolate or cover all porous zones. Following are the steps a licensee must complete when planning any abandonment operation.

Step 1: Identify the Type of Well Abandonment

An **open-hole well abandonment** is the downhole abandonment of a well after drilling is complete but before the rig is released. Surface abandonment occurs after downhole operations are complete. A **plug back** is the downhole abandonment of a portion of an open-hole well. A plugging program describes the planned placement of a series of plugs. Requirements for routine open-hole well abandonments and plug backs are in Section 4.

A **cased-hole well abandonment** is the downhole and surface abandonment of a completed or cased well. A **zonal abandonment** is the abandonment of a single pool completion within a cased-hole or the downhole abandonment of an open-hole interval in a cased hole. The requirements for routine cased-hole well and zonal abandonments are in Section 5.

Step 2: Determine if Planned Operation Is Routine or Nonroutine

Before beginning any work, the licensee must determine if the planned abandonment operation meets **all the requirements** that apply to the well based on the well type, its geographic location, and the impact of the well on any oil sands zones and whether the well has a wellbore problem.

If the planned surface or downhole abandonment operation is a **nonroutine operation**, continue with Step 3.

If the planned operation is a **routine surface abandonment** operation, skip to Step 4.

If the planned operation is a **routine downhole abandonment**, the licensee must submit a completion report via the DDS Well Records System (WRS) within 30 days after completing the operation. No other notifications to the EUB are required. Refer to *Directive 059: Well Drilling and Completion Data Filing Requirements*.

Step 3: Request EUB Approval for Nonroutine Abandonment Operations

The licensee must submit a request for approval of a planned nonroutine abandonment operation via the DDS Nonroutine Well Abandonment Request service. The request will be reviewed by the EUB Well Operations Section. The licensee may be asked to provide additional information regarding the planned nonroutine abandonment operation. The licensee will be notified once the request has been approved or denied. If the request is approved, the planned operation may begin.

Step 4: Perform Required Testing Before Surface Abandonment

The licensee must perform certain required tests on the well before beginning any routine or *approved* nonroutine surface abandonment operation. Depending on the type and

location of the well, the required tests may include fluid level testing (open-hole wells only), surface casing vent flow testing (cased-hole wells only), and gas migration testing (any type of well within the required test area).

Step 5: Report Completed Surface Abandonment

The licensee must inform all affected parties, including the landowner and/or occupant, of a planned surface abandonment before beginning any work.

The licensee must not begin surface abandonment until after the required testing has been performed and the test results indicate the absence of any wellbore problem. Unless a well is being abandoned due to an order of the EUB, surface abandonment must be completed within 12 months after downhole abandonment operations. If the well is being abandoned due to an order of the EUB, the licensee must begin surface abandonment as directed. Surface abandonment must be reported via the DDS Well Licence Abandonment service within 30 days of completing the operation.

Step 6: Complete Additional Reporting Requirements

In addition, the following information must also be submitted to the EUB:

- Tour reports must be submitted to the EUB according to the requirements in *Directive 059: Well Drilling and Completion Data Filing Requirements.*
- Plug logs must be submitted to the EUB's Resource Information Section within 30 days of completing downhole operations. Refer to Appendix 1.

3 Audit and Enforcement Process

The licensee must keep all test results and abandonment details for abandoned wells. If a licence for an abandoned well is transferred, the new licensee assumes all responsibility for monitoring the abandoned well. The EUB will use an audit system to confirm licensees' compliance and to help measure the effectiveness of the abandonment process. Upon written notification that the well has been selected for audit, the licensee must submit the required information within 20 days.

The EUB's enforcement process is specified in *Directive 019: EUB Compliance Assurance—Enforcement.* A list of risk-assessed noncompliances is available on the Web at EUB Home : Industry Zone : Compliance and Enforcement : Risk Assessed Noncompliance.

The EUB may order a licensee to re-enter and reabandon a well if conditions warrant.

4 Open-Hole Abandonment Requirements

The abandonment program for an open-hole well depends on the location of the well within the province and whether the well is in an oil sands area. For open-hole abandonments, the province is divided into four program areas: Western Alberta (Program Area 1), Northeastern Alberta (Program Area 2), East Central Alberta (Program Area 3), and Southeastern Alberta (Program Area 4) (see Figure 1). Designated oil sands areas exist in Program Areas 1 and 2.

Licensees of wells in Program Area 1 must develop their own plugging program that meets the plug requirements described in this directive. While the geology throughout Program Area 1 is too diverse to support a single plugging program, prescribed plugging programs have been developed by the EUB for Program Areas 2, 3, and 4. Licensees of wells in these program areas must follow the prescribed plugging program.

In an abandonment, the licensee must set cement plugs of sufficient length and number to ensure that crossflow between porous zones does not occur. Plugging programs must cover all nonsaline groundwater and must isolate or cover all porous zones. Approved groundwater isolation includes the identification and isolation of the base of usable groundwater from hydrocarbon formations below, as well as the identification and isolation of all formations of varying salinity. The EUB requires that all nonsaline groundwater be covered by cement. See *Statistical Series (ST)55: Alberta's Base of Groundwater Protection Information* on how to determine the groundwater protection depth for a well. Porous zones are defined as

- carbonates with effective porosity greater than 1 per cent, or
- sandstones with effective porosity greater than 3 per cent, or
- an offset production zone with a conglomerate, fractured carbonate, or fractured shale that has been produced from a well, regardless of the porosity, or
- any zone with drillstem test formation fluid recoveries greater than 300 linear metres or gas volumes greater than 300 cubic metres.

In wells that are not in an oil sands area, the use of fillers and/or additives in the cement used for plugs is acceptable in open-hole abandonments if the compressive strength of the mixture is at least 3500 kilopascals (kPa) after curing 48 hours. In wells that have penetrated oil sands zones, thermal cement must be used. Thermal cement is a blend that does not exhibit a significant reduction in strength when subjected to temperatures greater than 360.5° Celsius (C). Thermal cement must be used for the entire length of the plug.

Confirming Plug Placement

The licensee must confirm the location of all plugs using one of the approved methods described in Appendix 1. The only time a plug location does not have to be confirmed is when

- one stage of a multistage plug is placed, provided there is no loss of circulation;
- continuous cement is run from total depth to surface in one or more stages, provided there was no loss of circulation; or
- the top plug is placed, providing it is run to surface.

Plugs that are too low or too high or were misplaced are unacceptable (see Figure 2). The licensee must correct the misplaced plug and confirm the new location.

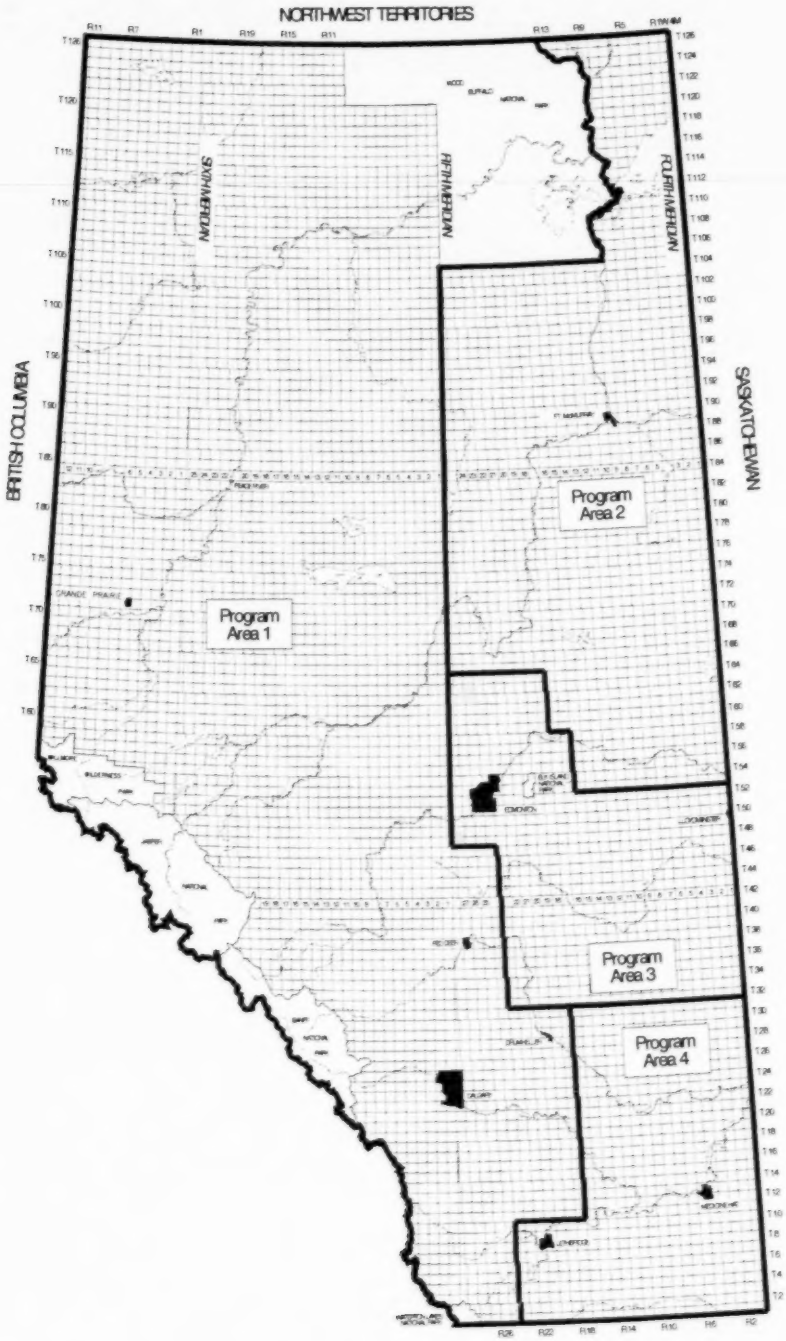


Figure 1. Area boundaries for all program areas

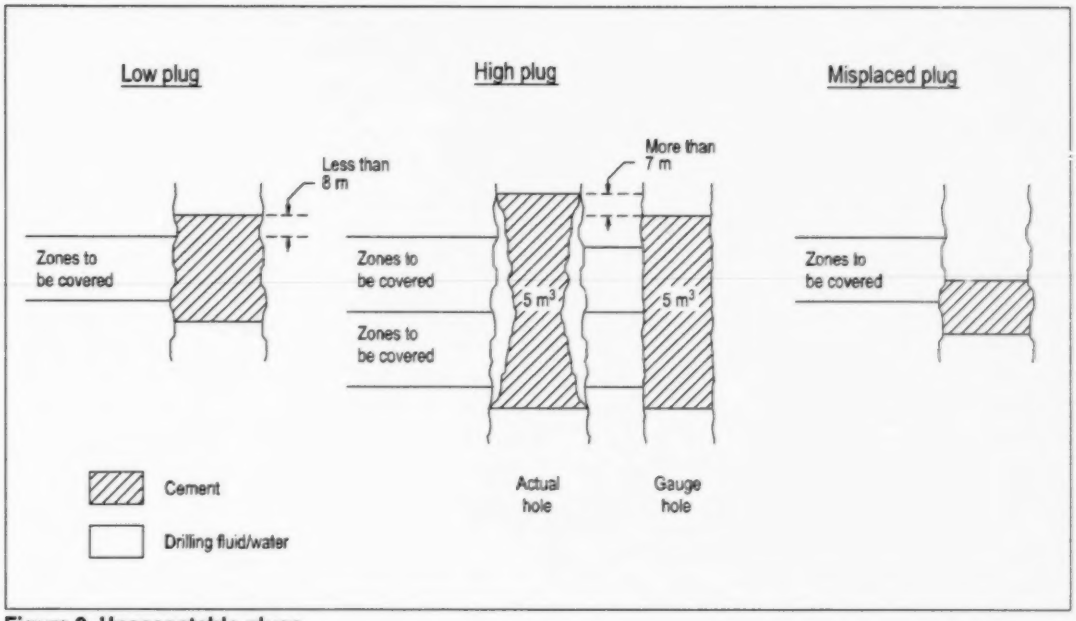


Figure 2. Unacceptable plugs

1) **Plug is too low:** The top of the plug top is less than 8 m above the top of the zone it was intended to cover.

   Action required: Low plugs must be built up and then the location confirmed.

2) **Plug is too high:** A plug is located more than 7 m above its theoretical top. To calculate a plug's theoretical top, use the formula

   Actual cement volume (m^3)/gauge hole volume (m^3/m) = X m

   Drill pipe setting depth (m) – X m = Theoretical top

   Action required: High plugs must be circulated out or drilled out. The plug must be rerun and its location confirmed.

3) **Plug is misplaced:** The plug was positioned in such a way that it did not cover the zone(s) it was intended to cover.

   Action required: Depending on its position, a misplaced plug may first have to be circulated out or drilled out. The plug must be rerun and its location confirmed.

4.1 Oil Sands Evaluation Wells and Test Hole Wells

Oil Sands Evaluation and Test Hole wells (as identified by OV and TH respectively on the licence's Lahee Classification) have specific abandonment requirements. These wells are drilled for core samples only and are not intended to be completed. Downhole abandonment operations on these wells must be completed within 30 days after drilling has finished. Oil Sands Evaluation wells must be filled with thermal cement from final total depth to surface.

Test hole wells that are drilled outside a designated oil sands area must be filled with class "G" cement from final total depth to surface. Fluid level tests and gas migration tests are not required. Surface abandonment operations must be completed immediately after downhole operations. Oil Sands Evaluation and Test Hole well abandonments are considered routine and must be reported within 30 days of completing the surface abandonment.

4.2 Wells in Program Area 1 (Western Alberta)

Licensees wanting to abandon wells in Program Area 1 must develop a plugging program that meets the plug requirements described in this section. Due to the geological diversity of Program Area 1, a prescribed plugging program has not been developed. (See Figure 3.)

Program Area 1
Townships 1–10, Ranges 25, W4M – 6 W5M
Townships 11–31, Ranges 18, W4M – 12 W5M
Townships 32–47, Ranges 24, W4M – 25 W5M
Townships 48–126, Range 1, W5M – 14 W6M

Athabasca Oil Sands Area
Township 75, Ranges 1-2, W5M
Townships 76-87, Ranges 1-4, W5M
Townships 88-92, Ranges 1-7, W5M
Townships 93-103, Ranges 1-6, W5M

Peace River Oil Sands Area
Townships 78-82, Ranges 11-25, W5M
Townships 83-87, Ranges 11-24, W5M
Townships 88-92, Ranges 8-24, W5M
Townships 93-99, Ranges 7-17, W5M

Licensees must use the logs from their own well to determine the exact plug placement for the well based on the requirements for Program Area 1:

- All plugs run at a depth less than 1500 m must be a minimum length of 30 m, and they must extend a minimum of 15 m below and a minimum of 15 m above the porous zone being covered.
- All plugs run at a depth greater than 1500 m must be a minimum length of 60 m, and they must extend a minimum of 15 m below and a minimum of 15 m above the porous zone being covered.
- A plug may extend over more than one porous zone.
- There is no minimum distance between plugs as long as the pressure from the zone being isolated does not exceed the fracture pressure of the interval left open above it.
- Any plug may be staged; however, the break between stages in a multistage plug must occur within a zone and may not occur at a zone top.
- The location of each plug must be confirmed by one of the approved methods described in Appendix 1.

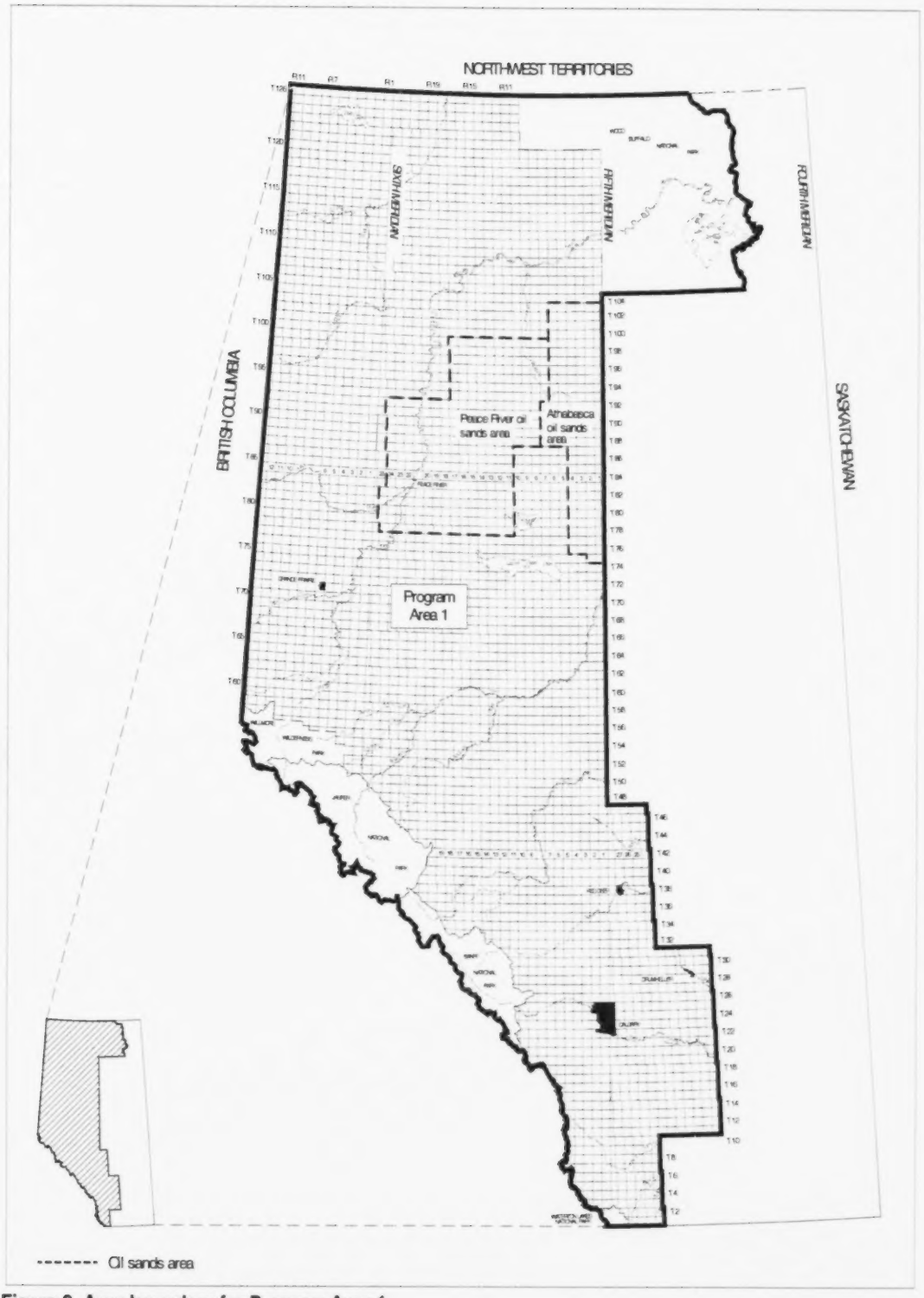


Figure 3. Area boundary for Program Area 1

- Thermal cement blends must be used when abandoning wellbores that access or pass through oil sands.

The requirements for protecting nonsaline groundwater are as follows:

- In a well where the surface casing is set above the base of groundwater protection, a plug must be run from 15 m below the base of the nonsaline groundwater to 15 m above the surface casing shoe.

- In a well in which intermediate casing has been run but has not been cemented full length and the surface casing is set above the base of groundwater protection, the EUB requires remedial cementing to cover groundwater.

- In a well where surface casing is set below the base of groundwater protection, a plug must extend from a minimum of 15 m below the surface casing shoe to 15 m above it.

Figure 4 provides examples of plug placement within Program Area 1.

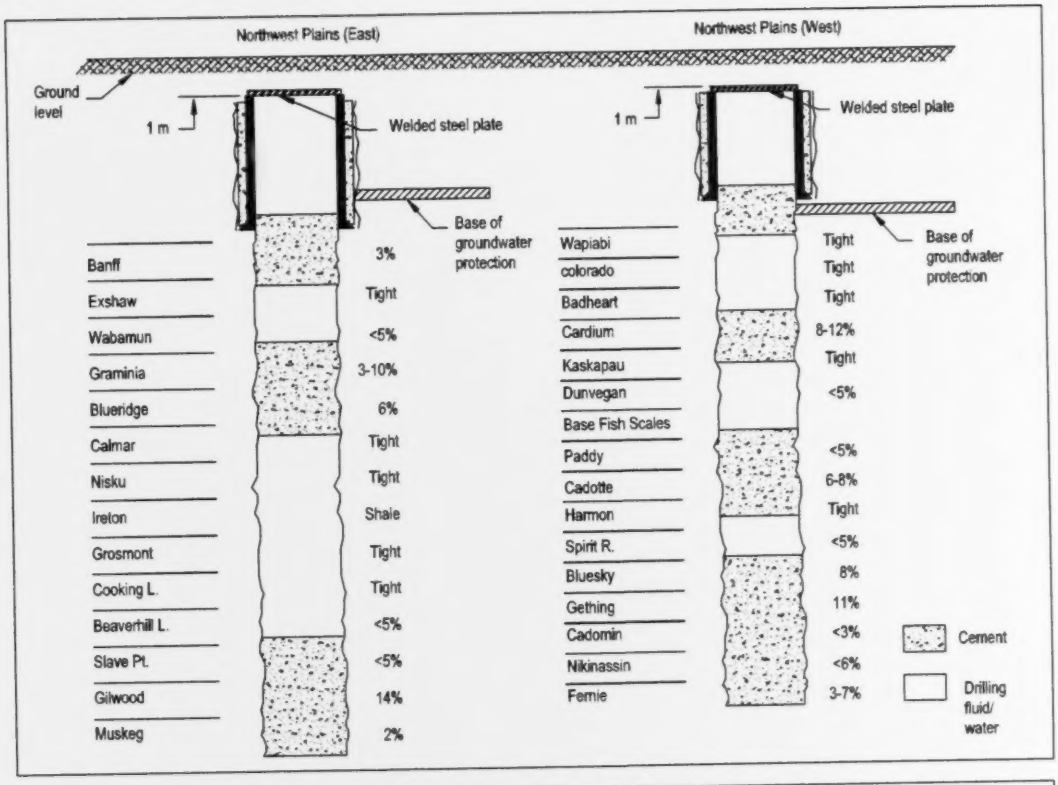
4.3 Wells in Program Area 2 (Northeastern Alberta)

Licensees wanting to abandon wells in Program Area 2 (see Figure 5) must follow the prescribed plugging program described in this section.

Program Area 2
Townships 53–58, Ranges 1–15, W4M
Townships 59–64, Ranges 1–17, W4M
Townships 65–126, Ranges 1–27, W4M

Athabasca Oil Sands Area
Townships 62-66, Ranges 12-15, W4M
Townships 67-68, Ranges 9-15, W4M
Township 69, Ranges 9-16, W4M
Township 70, Ranges 2-17, W4M
Township 71, Ranges 2-24, W4M
Townships 73-74, Ranges 4-26, W4M
Township 75, Range 4, W4–2W5M
Townships 76-85, Range 4, W4–4W5M
Townships 86-87, Range 1, W4–4W5M
Townships 88-92, Range 1, W4–7W5M
Townships 93-100, Range 1, W4–6W5M
Townships 101–103, Range 4, W4–6W5M

Cold Lake Oil Sands Area
Townships 53-54, Ranges 1-9, W4M
Townships 53-61, Ranges 1-13, W4M
Townships 62-66, Ranges 1-11, W4M
Townships 67-69, Ranges 1-8, W4M



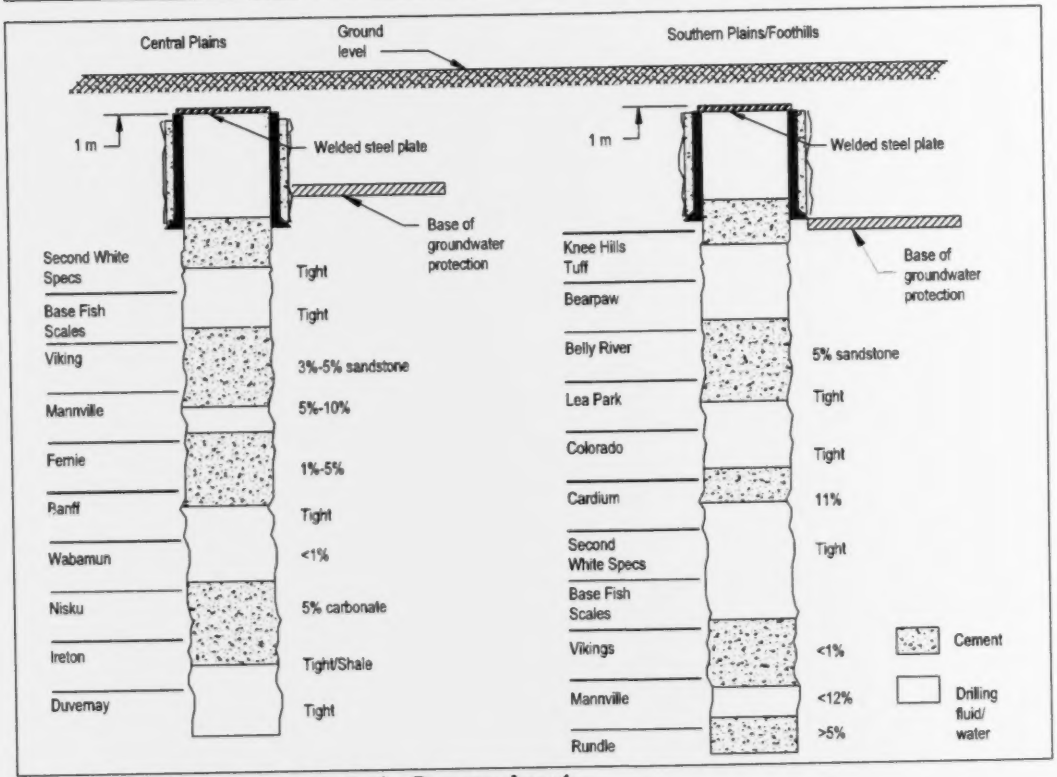


Figure 4. Plug placement examples for Program Area 1

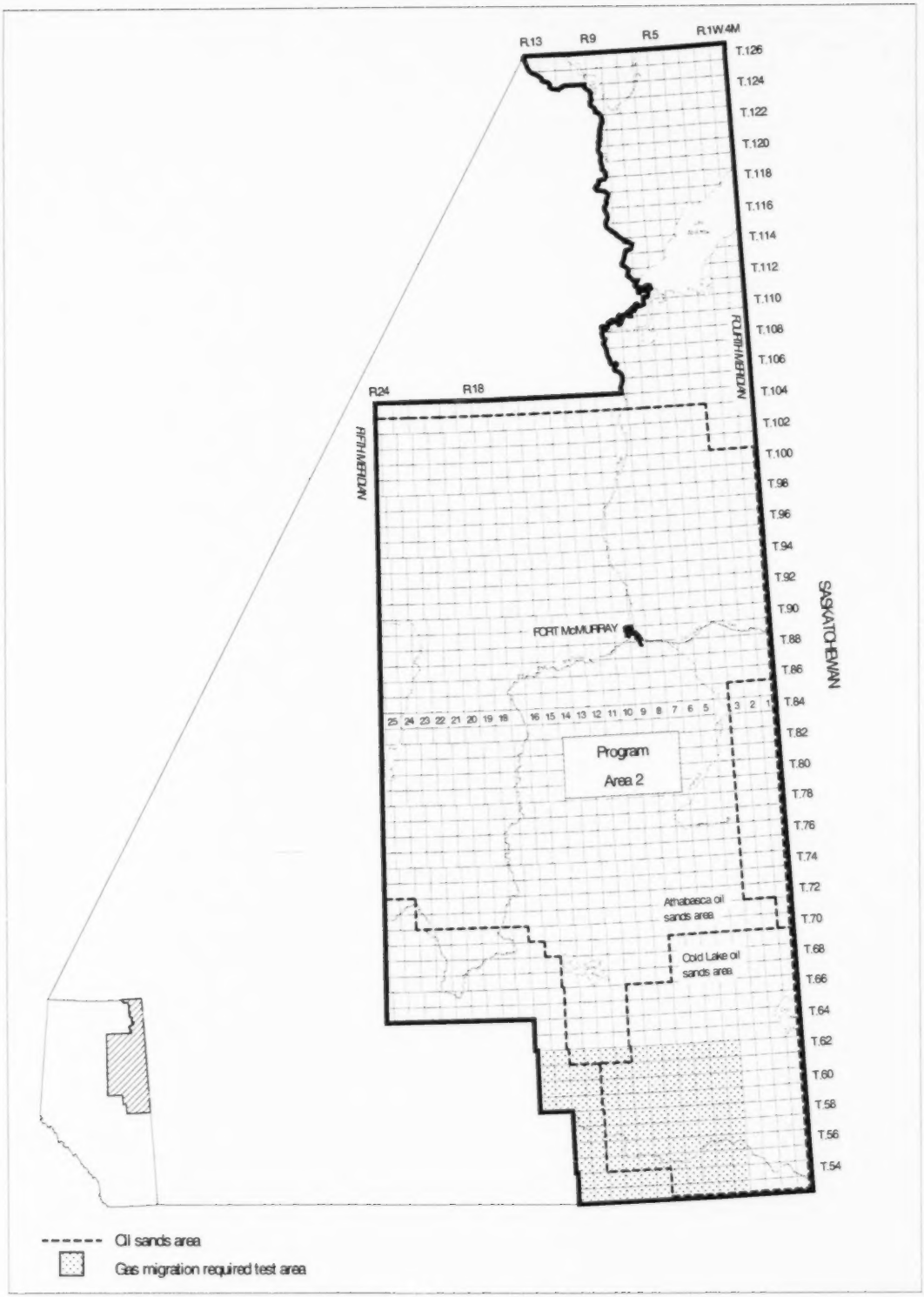


Figure 5. Area boundary for Program Area 2

Licensees must use the logs from their own well to determine the exact plug placement for the well based on the requirements for Program Area 2:

- All plugs run at a depth less than 1500 m must be a minimum length of 30 m, and they must extend a minimum of 15 m below and a minimum of 15 m above the porous zone being covered.
- All plugs run at a depth greater than 1500 m must be a minimum length of 60 m, and they must extend a minimum of 15 m below and a minimum of 15 m above the porous zone being covered.
- A plug may extend over more than one porous zone.
- There is no minimum distance between plugs as long as the pressure from the zone being isolated does not exceed the fracture pressure of the interval left open above it.
- Any plug may be staged; however, the break between stages in a multistage plug must occur within a zone and may not occur at a zone top.
- The location of each plug must be confirmed by one of the approved methods described in Appendix 1.

4.3.1 Prescribed Plugging Program for Non-Oil Sands Wells

Wells in Program Area 2 (but not within the Cold Lake or Athabasca oil sands areas) must follow the prescribed plugging program described in this subsection.

Bottom Plug

A bottom plug must be set from the well's total depth to a minimum of 15 m above the top of the Grand Rapids Formation (Mannville Group).

Top Plug

A top plug must be set from a minimum of 15 m below the top of the Viking Formation to a minimum of 15 m above the surface casing shoe.

4.3.2 Prescribed Plugging Program for Oil Sands Wells

Wells within the Cold Lake or Athabasca oil sands areas must follow the prescribed plugging program described in this subsection (see Figure 6).

Bottom Plug

A bottom plug must be set from the well's total depth to a minimum of 15 m above the top of the Grand Rapids Formation (Mannville group) using thermal cement. Excess cement above the top of the plug must be reverse circulated to surface.

Top Plug

A top plug must be set from a minimum of 15 m above the top of the Grand Rapids Formation (Mannville group) to a minimum of 15 m above the surface casing shoe.

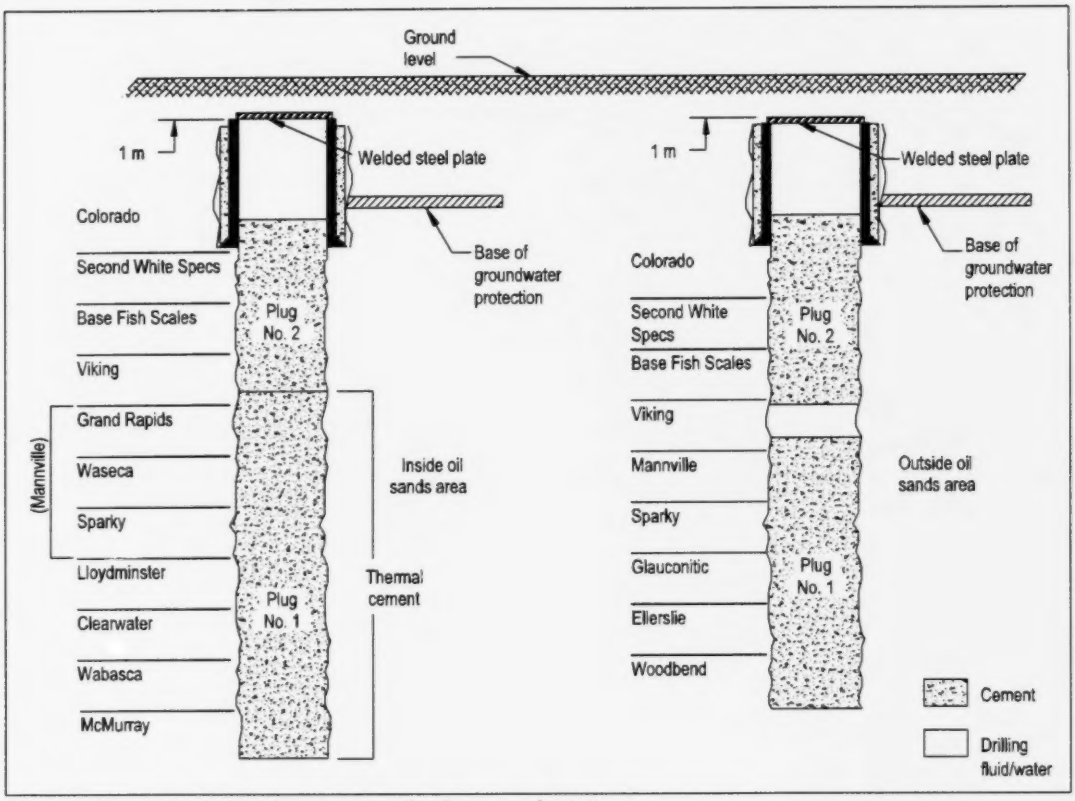


Figure 6. Prescribed plugging program for Program Area 2

4.4 Wells in Program Area 3 (East Central Alberta)

Licensees wanting to abandon wells in Program Area 3 (see Figure 7) must follow the prescribed plugging program described in this section.

Program Area 3
Townships 32–47, Ranges 1–23, W4M
Townships 48–52, Ranges 1–28, W4M
Townships 53–58, Ranges 16–28, W4M
Townships 59–64, Ranges 18–27, W4M

Licensees must use the logs from their own well to determine the exact plug placement for the well based on the requirements for Program Area 3:

- All plugs run at a depth less than 1500 m must be a minimum length of 30 m, and they must extend a minimum of 15 m below and a minimum of 15 m above the porous zone being covered.

- All plugs run at a depth greater than 1500 m must be a minimum length of 60 m, and they must extend a minimum of 15 m below and a minimum of 15 m above the porous zone being covered.

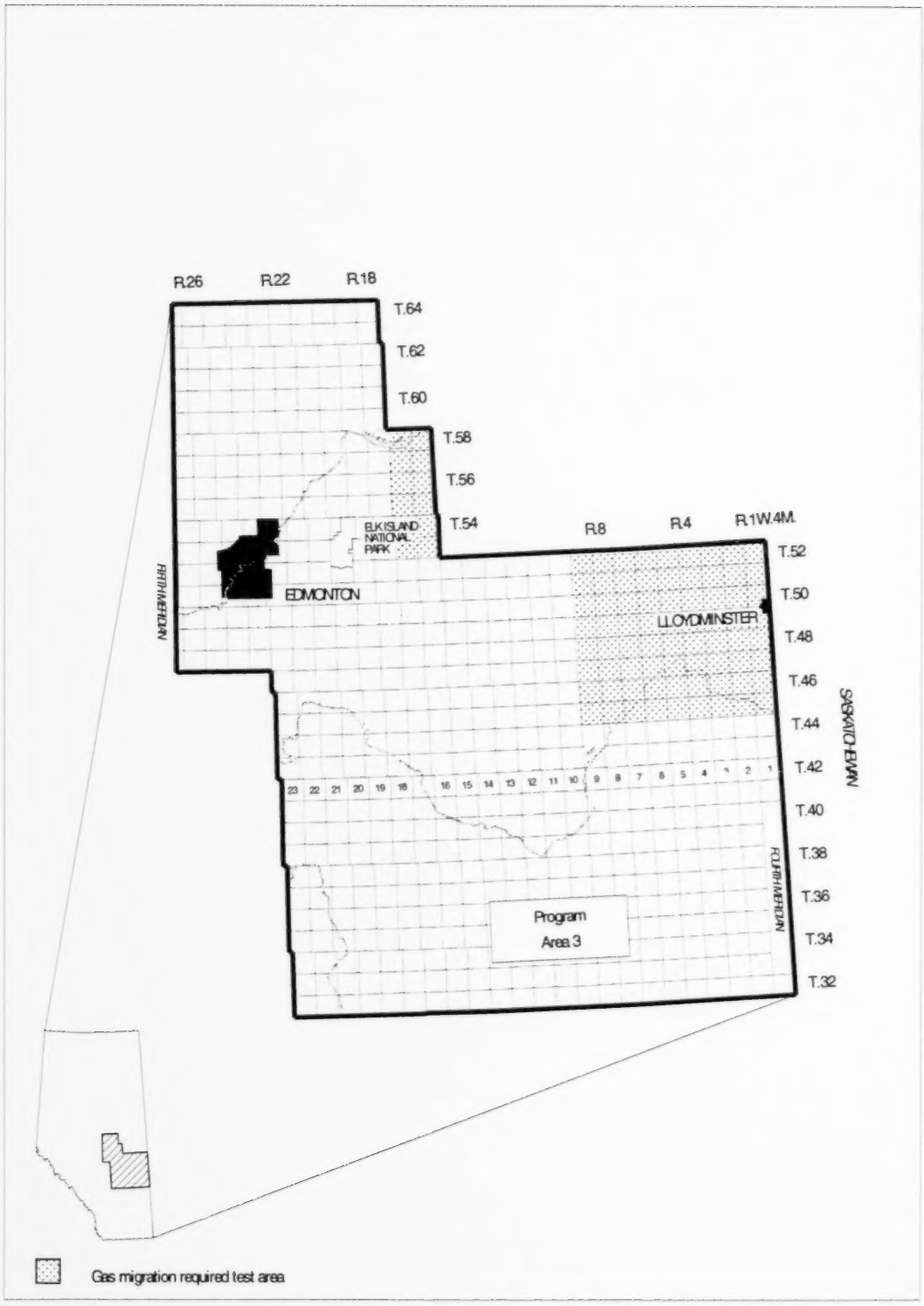


Figure 7. Area boundary for Program Area 3

- A plug may extend over more than one porous zone.
- There is no minimum distance between plugs as long as the pressure from the zone being isolated does not exceed the fracture pressure of the interval left open above it.
- Any plug may be staged; however, the break between stages in a multistage plug must occur within a zone and may not occur at a zone top.
- The location of each plug must be confirmed by one of the approved methods described in Appendix 1.

4.4.1 Prescribed Plugging Program

Wells in Program Area 3 must follow the prescribed plugging program described here (see Figure 8).

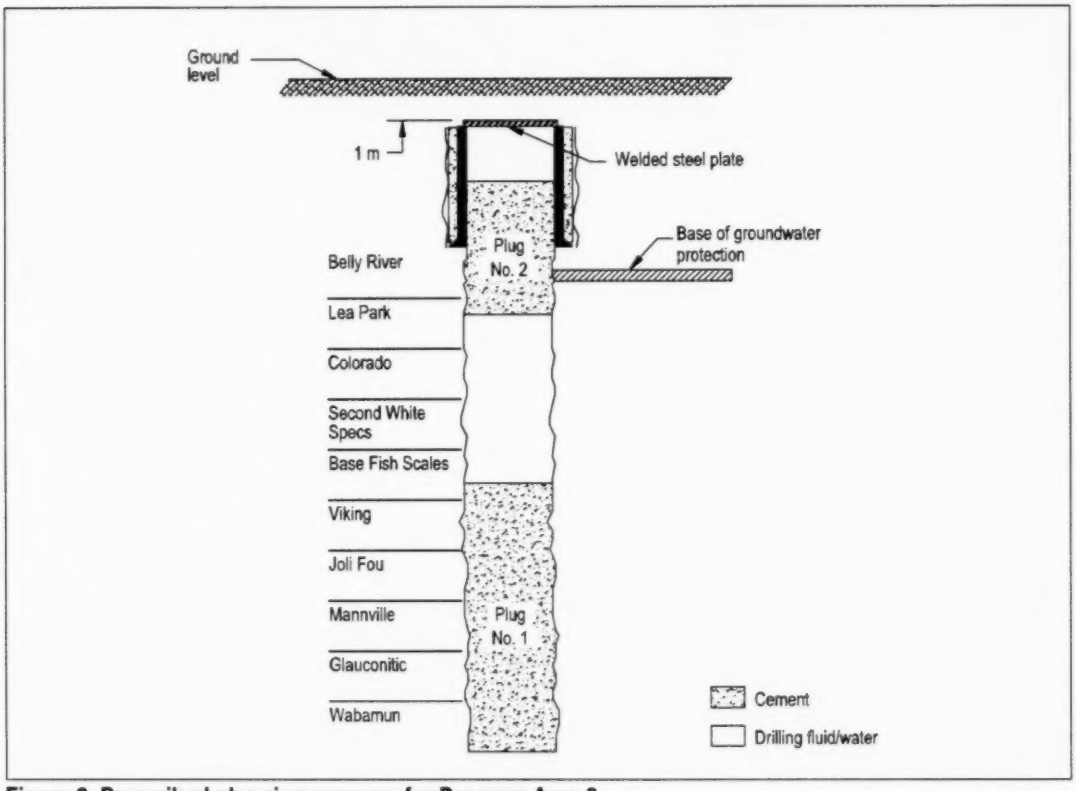


Figure 8. Prescribed plugging program for Program Area 3

Bottom and Intermediate Plugs

If the well's total depth is shallower than the Wabamun Formation, a bottom plug must be set from the well's total depth to a minimum of 15 m above the top of the Viking Formation. An intermediate plug is not needed.

If the well's total depth is deeper than the Wabamun Formation, a bottom plug must be set from the well's total depth to a minimum of 15 m above the top of the Nisku Formation. An intermediate plug must be set a minimum of 15 m below the base of the Wabamun to a minimum of 15 m above the top of the Viking Formation.

Top Plug

A top plug must be set from a minimum of 15 m below the top of the Lea Park Formation to a minimum of 15 m above the surface casing shoe.

4.5 Wells in Program Area 4 (Southeastern Alberta)

Licensees wanting to abandon wells in Program Area 4 (see Figure 9) must follow the prescribed plugging program described in this section.

Program Area 4
Townships 1–10, Ranges 1–24, W4M
Townships 11–31, Ranges 1–17, W4M

Site Inspection Region within Program Area 4
Townships 7–14, Ranges 12–17, W4M
Townships 15–18, Ranges 10–13, W4M

Licensees must use the logs from their own well to determine the exact plug placement for the well based on the requirements for Program Area 4:

- All plugs run at a depth less than 1500 m must be a minimum length of 30 m, and they must extend a minimum of 15 m below and a minimum of 15 m above the porous zone being covered.
- All plugs run at a depth greater than 1500 m must be a minimum length of 60 m, and they must extend a minimum of 15 m below and a minimum of 15 m above the porous zone being covered.
- A plug may extend over more than one porous zone.
- There is no minimum distance between plugs as long as the pressure from the zone being isolated does not exceed the fracture pressure of the interval left open above it.
- Any plug may be staged; however, the break between stages in a multistage plug must occur within a zone and may not occur at a zone top.
- The location of each plug must be confirmed by one of the approved methods described in Appendix 1.

4.5.1 Prescribed Plugging Program

The prescribed plugging program for wells in Program Area 4 (see Figure 10) depends on whether the Medicine Hat Formation has more than 3 per cent porosity.

4.5.1.1 Wells with Less Than 3 per cent Porosity in the Medicine Hat Formation

Wells with less than 3 per cent porosity in the Medicine Hat Formation are not required to isolate the Second White Specs Formation.

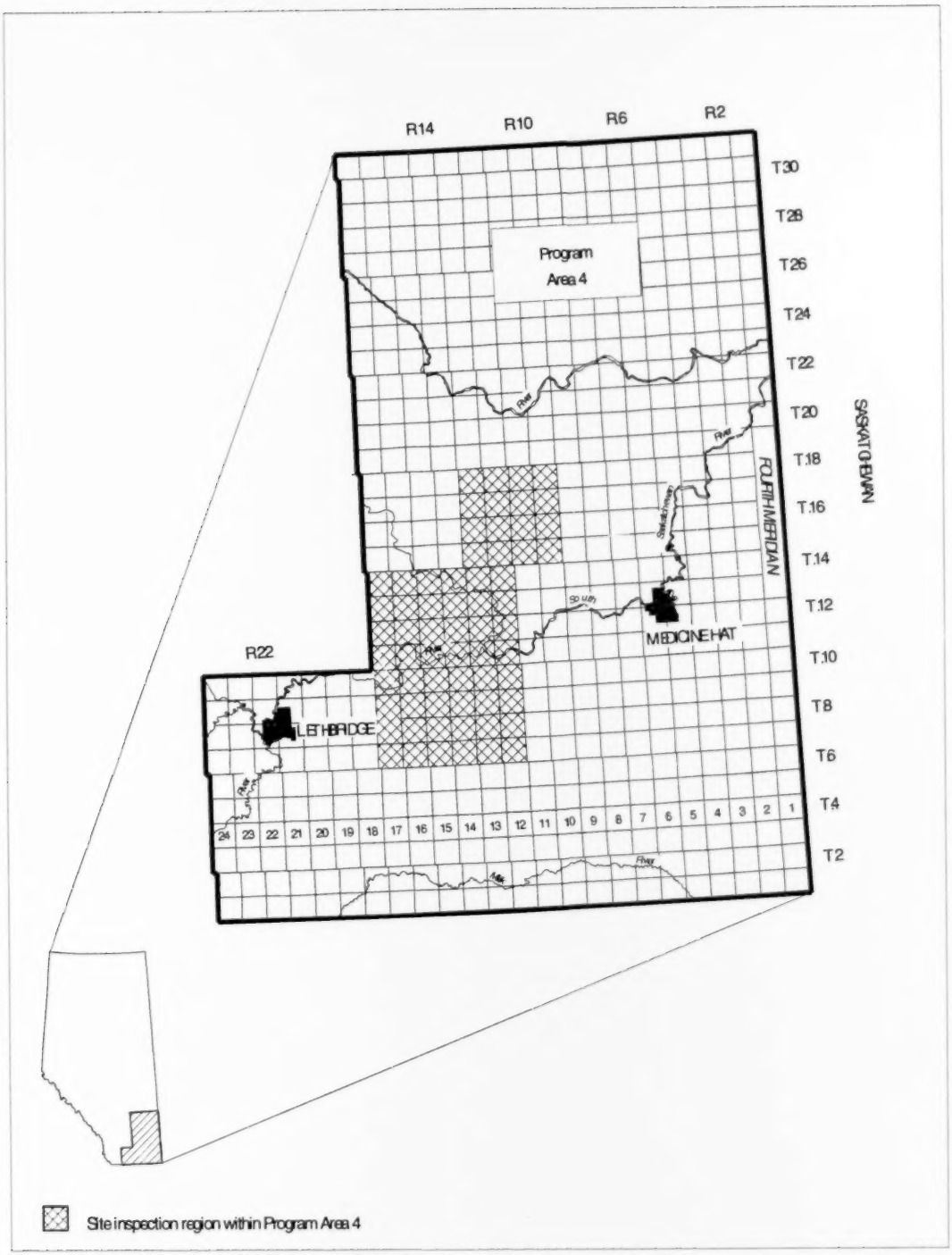


Figure 9. Area boundary for Program Area 4

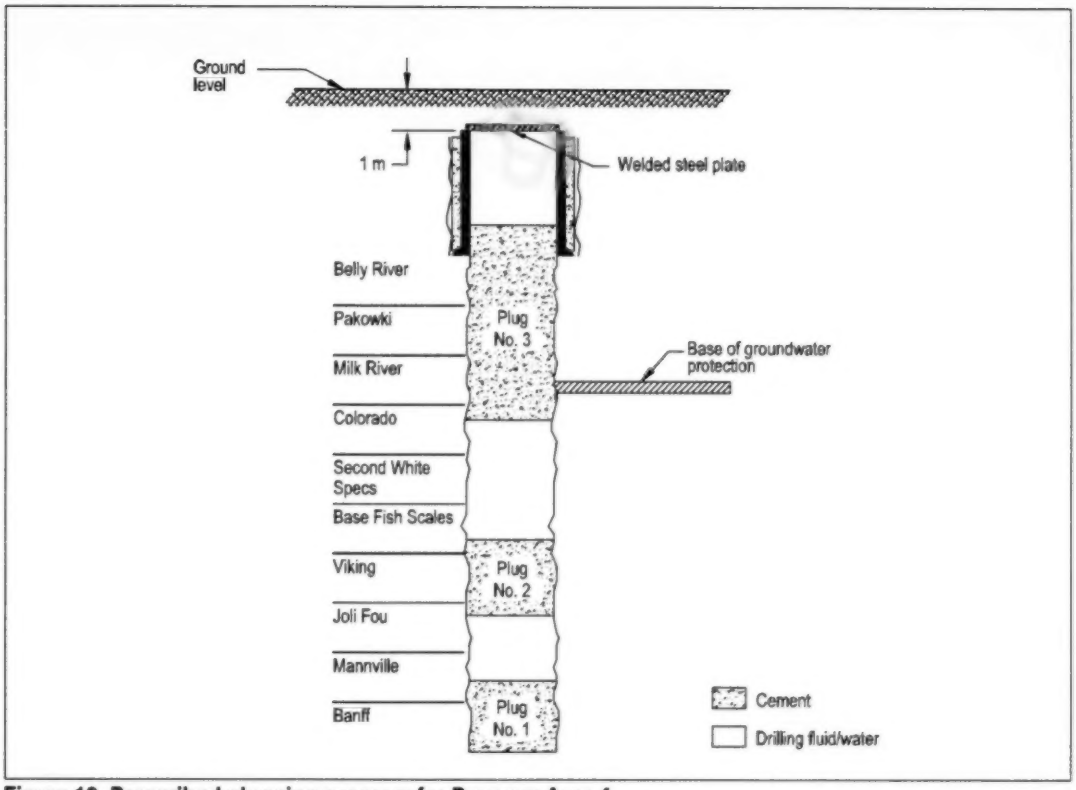


Figure 10. Prescribed plugging program for Program Area 4

Bottom Plug

A bottom plug must be set from the well's total depth to a minimum of 15 m above the base of the Mannville Formation.

Intermediate Plug

An intermediate plug must be set from a minimum of 15 m below the base of the Viking/Bow Island Formation to a minimum of 15 m above the top of the Viking/Bow Island Formation.

Top Plug

A top plug must be set from 15 m below the base of the Milk River Formation to 15 m above the surface casing shoe.

4.5.1.2 Wells with More Than 3 per cent Porosity in the Medicine Hat Formation

Wells with more than 3 per cent porosity in the Medicine Hat Formation are required to isolate the Second White Specs Formation. There are two options for isolating the White Specs Formation (see Figure 11).

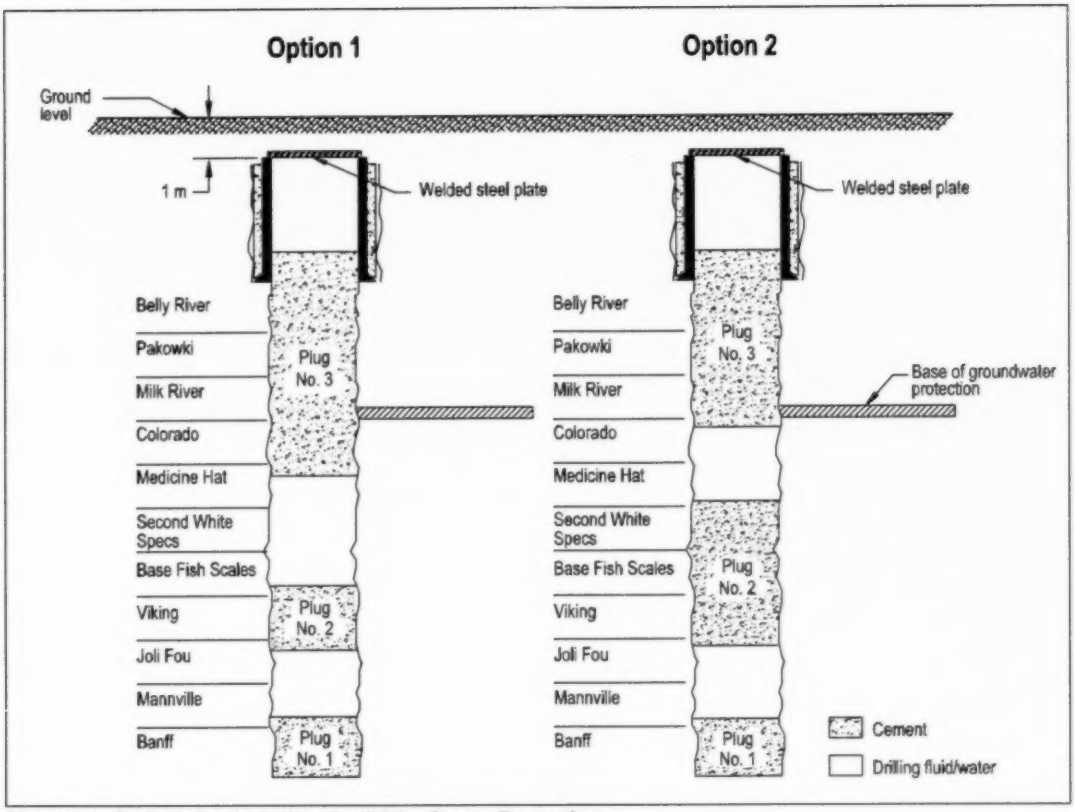


Figure 11. Options for isolating the White Specs Formation

Option 1

Bottom Plug

A bottom plug must be set from the well's total depth to a minimum of 15 m above the base of the Mannville Formation.

Intermediate Plug

An intermediate plug must be set from a minimum of 15 m below the base of the Viking/Bow Island Formation to a minimum of 15 m above the top of the Viking/Bow Island Formation.

Top Plug

A top plug must be set a minimum of 15 m below the base of the Medicine Hat Formation to a minimum of 15 m above the surface casing shoe.

Option 2

Bottom Plug

A bottom plug must be set from the well's total depth to a minimum of 15 m above the base of the Mannville Formation.

Intermediate Plug

An intermediate plug must be set from a minimum of 15 m below the base of the Viking/Bow Island Formation to a minimum of 15 m above the top of the Second White Specs Formation.

Top Plug

A top plug must be set from a minimum of 15 m below the base of the Milk River formation to a minimum of 15 m above the surface casing shoe.

4.5.2 Inspection Requirements for Wells in Program Area 4

If a well is in the designated "site inspection region" for Program Area 4, the licensee must wait until the well passes an EUB site inspection before cutting and capping the well. To schedule a site inspection, the licensee must contact the EUB Medicine Hat Field Centre at (403) 527-3385 within 24 hours after conducting downhole abandonment operations. The licensee must provide the well location and a company contact name and phone number. The Medicine Hat Field Centre will arrange a site inspection of the well. Until the well has been inspected, the surface casing must be left open, with fluid visible and protected from freezing. The well will be visually inspected by EUB staff for leaking plugs and the results communicated to the licensee.

4.6 Surface Abandonment

Surface abandonment is the cutting off of casing string(s) and the capping of a well. Surface abandonment must be reported via the DDS Well Licence Abandonment service within 30 days of completing the operation.

Surface equipment, cement pads, debris, and produced liquids associated with the well licence must be removed within 12 months of the cutting and capping operation. Record of the removal and cleanup activities must be retained by the licensee and may be requested in an audit.

4.6.1 Testing

Before beginning any routine or approved nonroutine surface abandonment operation, the licensee must perform certain required tests on the well. It is advisable to perform testing prior to beginning downhole abandonment operations to avoid having to re-enter the well to correct a wellbore problem.

Fluid Level Test

The licensee must conduct a *fluid level test* to determine if there are any leaking plugs. The fluid level test must be performed a minimum of 5 days after downhole abandonment operations have been completed and before surface abandonment operations begin. To

perform the test, the licensee must visually inspect the well to ensure that the fluid level inside the casing is static. In the event of a leaking plug, the licensee must prepare a reabandonment program and submit a nonroutine abandonment request via the DDS Nonroutine Abandonment Request service within 30 days of discovery of the leaking plug.

Gas Migration (GM) Test

The licensee must conduct a *gas migration test* in the required test area to determine if gas is detectable outside the outermost casing string. As required in *ID 2003-01*, a licensee must check all wells in the required test area (see Figure 12) for gas migration prior to surface abandonment. Although not a requirement, the EUB believes all wells should be tested for gas migration prior to abandonment. See Appendix 2 for recommended test procedures. If a gas migration problem is detected, the licensee must notify the EUB via the DDS Surface Casing Vent Flow/Gas Migration (SCVF/GM) service within 30 days of detection.

Required Test Area
Townships 45-52, Ranges 1-9, W4M
Townships 53-62, Ranges 4-17, W4M

If gas migration is discovered *after* surface abandonment has been completed on a well, the licensee must notify the EUB via the DDS Surface Casing Vent Flow/Gas Migration (SCVF/GM) service within 30 days of detection. The licensee is required to re-enter and reabandon the well after requesting approval for a nonroutine abandonment.

4.6.2 Cutting and Capping

The licensee may not begin surface abandonment if any test result indicates a wellbore problem.

Surface abandonment consists of cutting the casing string(s) off at a specific depth below the well's final contour elevation. The casing strings must be cut off a minimum of 2 m below final contour elevation if the well is

- in an area with special farming practices, such as deep tillage, drainage works, or peat lands, or
- within 15 kilometres (km) of urban development.

If the well is not in located in an area with special farming practices or within 15 km of urban development, the casing string(s) must be cut off a minimum of 1 m below the final contour elevation.

Any intermediate casing string must be plugged at surface with either
- a minimum 8 linear metre cement slurry on top of a wiper plug, or
- a steel plate welded cross the casing string.

The surface casing must be sealed at surface with a steel plate welded across the surface casing. The steel plate must be metallurgically compatible to the casing and welded according to industry standards to eliminate the possibility of creating corrosive cells that may occur when dissimilar materials are used. Record of the type of steel plate and welding procedure used must be retained by the licensee and may be requested in an audit.

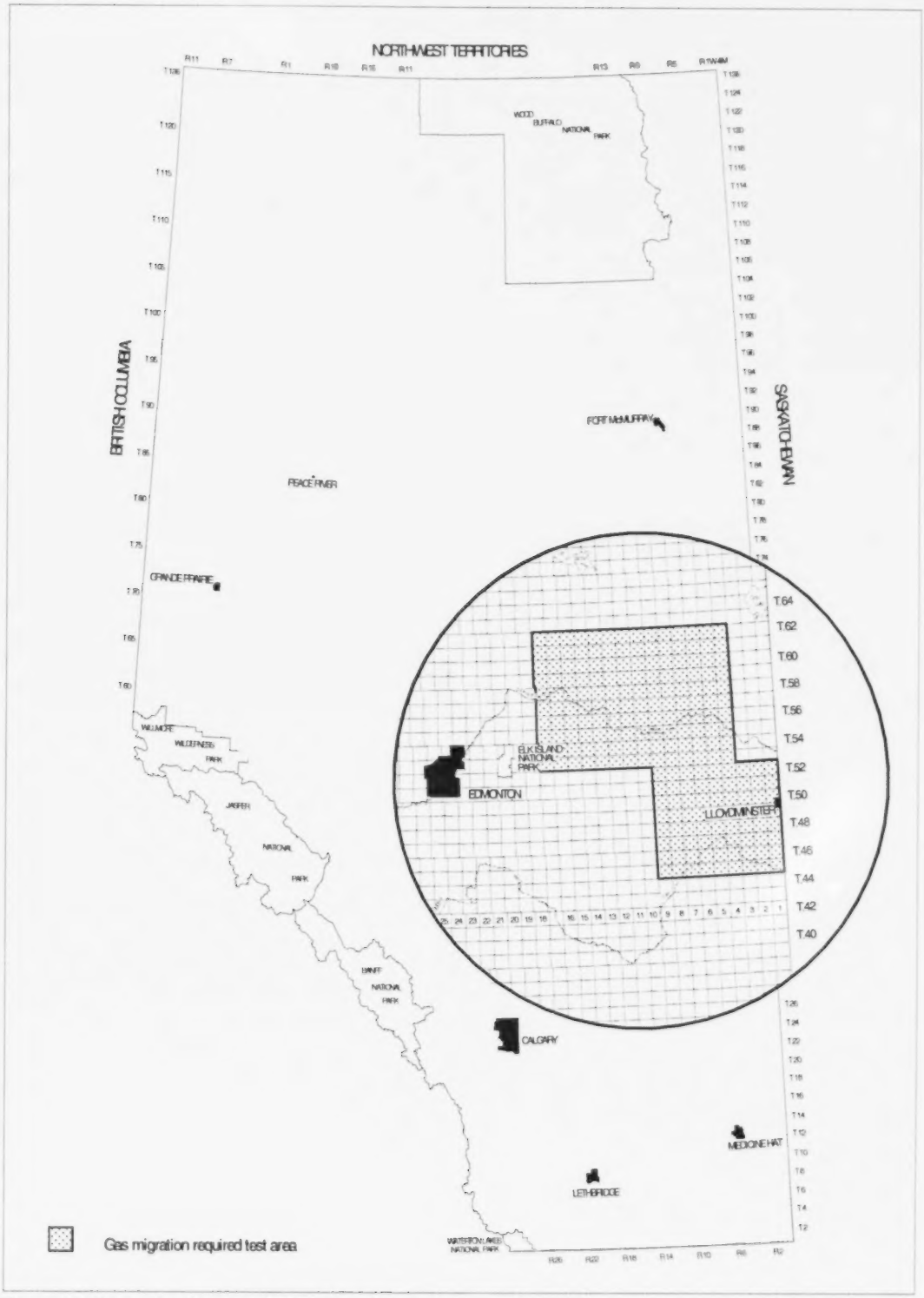


Figure 12. Gas migration required test area

5 Cased-Hole Abandonment Requirements

The abandonment program for a cased-hole well depends on the location of the well, if the well was completed, and if the well penetrated any oil sands zones. In a cased-hole abandonment, the licensee must abandon each completed pool separately and must cover all nonsaline groundwater with cement.

The licensee must review the existing cement behind the casing string(s) of a well before beginning abandonment operations. If the casing string(s) in a cased-hole well were not cemented according to the requirements in *Directive 009: Casing Cementing Minimum Requirements*, the cement location and condition must be evaluated. The licensee must determine that hydraulic isolation exists between porous zones (using the porosity definition in Section 4: Open-Hole Abandonment Requirements). The licensee may be required to perform remedial downhole work before the final abandonment of the well in order to establish isolation between porous zones.

5.1 Wells Not Penetrating Oil Sands Zones

The following are the requirements for abandonment operations on cased-hole wells that *do not* penetrate oil sands zones. Abandonment operations for cased-hole wells that adhere to these requirements are routine. After each completed interval is abandoned, the wellbore must have an inhibitor added to prevent corrosion.

5.1.1 Noncompleted Wells

Noncompleted wells (i.e., wells that do not have any perforations) do not require additional cement plugs to be run if the existing casing string is pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

5.1.2 Wells with a Cemented Liner

To abandon a well with a cemented liner, a minimum 30 m cement plug is required to be run across the liner top (i.e., the hanger). For deviated wells, the cement plug length must equate to 30 vertical metres of cement. The plug must extend from a minimum of 15 m below the liner top to a minimum of 15 m above the liner top. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

5.1.3 Wells with an Uncemented Liner

To abandon a well with an uncemented liner across more than one formation, the well must be abandoned according to the open-hole abandonment requirements. The zones behind the liner must be evaluated for porosity, and the porous zones must be covered by cement or isolated between cement plugs. Once the liner has been cemented, a minimum 30 m cement plug is required to be run across the liner top (i.e., the hanger). For deviated wells, the cement plug length must equate to 30 vertical metres of cement. The plug must extend from a minimum of 15 m below the liner top to a minimum of 15 m above the liner top. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

5.1.4 Zonal Abandonment within a Completed Well

The licensee must use one of the following methods for abandoning zones within a completed well.

Option 1–Setting a Bridge Plug

A bridge plug must be set within 15 m above the perforation or the single-zone open-hole section. Once the bridge plug has been set, it must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The plug must be capped with either a minimum of 8 linear metres of class "G" cement or with a minimum of 3 m of hydromite.

Option 2–Setting a Cement Retainer

A cement retainer must be set within 15 m above the perforations or the single-zone open-hole section. The retainer must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. A cement squeeze must be conducted into the perforations or the single-zone open-hole section. The retainer must be capped with a minimum of 8 linear metres of class "G" cement. If this plug is to be drilled out, the squeezed interval must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

Option 3–Setting a Plug in a Permanent Packer

A plug must be set in a permanent packer within 15 m above the perforation or the single-zone open-hole section. The plug and packer must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. Then the plug and packer must be capped with either a minimum of 8 linear metres of class "G" cement or with a minimum of 3 m of hydromite.

Option 4–Squeezing Cement

A cement squeeze must be conducted into the perforations or the single-zone open-hole section. After the cement has set, the top of the cement must be confirmed by one of the approved methods described in Appendix 1. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The plug must extend from a minimum of 15 m below the completion or total depth, whichever is shallower, to a minimum of 15 m above the completion. If this plug is to be drilled out, the squeezed interval must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

Option 5–Setting a Cement Plug

A cement plug must be set across the perforations or the single-zone open-hole section. The plug must extend a minimum of 15 m above the top of the completed interval and a minimum of 15 m below either the completed interval or the plug-back total depth, whichever is shallower. The location of the plug must be confirmed by one of the approved methods described in Appendix 1. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

5.1.5 Completed Horizontal Wells in a Single Formation

In a horizontal open-hole interval that penetrates one formation, a bridge plug must be set within 15 m TVD of the top of the formation in which the horizontal zone is completed. Once the bridge plug has been set, it must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The plug must be capped with either a minimum of 8 vertical metres of class "G" cement or a minimum of 3 vertical metres of hydromite.

5.1.6 Completed Horizontal Wells across Multiple Formations

In a horizontal open-hole interval that penetrates multiple formations, each formation must have a cement plug set in the open-hole section to either cover or isolate the porous zones within the different formations. A minimum 30 vertical metre cement plug is required, extending either a minimum of 15 m below the formation or the plug-back total depth, whichever is shallower, to a minimum of 15 m above the porous zone. The location of the plug must be confirmed by one of the approved methods described in Appendix 1.

5.2 Wells Penetrating Oil Sands Zones

The following are the requirements for abandonment operations on cased-hole wells that penetrate oil sands zones. Abandonment operations for cased-hole wells that adhere to these requirements are routine.

5.2.1 Noncompleted Wells

All noncompleted oil sands zones must have a thermal cement plug run across the oil sands formation with a minimum of 15 m of thermal cement above the top of the formation and a minimum of 15 m below the formation or the plug-back total depth, whichever is shallower. This plug may be combined into a longer plug to cover two or more uncompleted oil sands zones. The location of the cement plug must be confirmed by one of the approved methods described in Appendix 1. Then, the plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

5.2.2 Completed Wells

If the well being abandoned penetrates an oil sands zone, *each oil sands zone* that is penetrated must be abandoned using one of the following methods. The licensee must review the well logs to determine which oil sands zones have been penetrated by the well. After each completed interval is abandoned, the wellbore must have an inhibitor added to prevent corrosion. Thermal cement must be used when abandoning wellbores that penetrate oil sands.

Option 1–Setting a Bridge Plug

A bridge plug must be set within 15 m above the perforations or the single-zone open-hole section. Once the bridge plug has been set, it must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. Then the plug must be capped with a minimum of 8 linear metres of thermal cement. The cement top must extend to a minimum of 15 m above the formation top.

Option 2–Setting a Cement Retainer

A cement retainer must be set within 15 m above the perforations or the single-zone open-hole section. The retainer must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. A thermal cement squeeze must be conducted into the perforations or the single-zone open-hole section. The retainer must be capped with a minimum of 8 linear metres of thermal cement. The cement top must extend to a minimum of 15 m above the formation top. If this plug is to be drilled out, the squeezed interval must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

Option 3–Setting a Plug in a Permanent Packer

A plug must be set in a permanent packer within 15 m above the perforation or the single-zone open-hole section. The plug and packer must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. Then, the plug and packer must be capped with a minimum of 8 linear metres of thermal cement. The cement top must extend to a minimum of 15 m above the formation top.

Option 4–Squeezing Cement

A thermal cement squeeze must be conducted into the perforations or the single-zone open-hole section. After the cement has set, the top of the cement must be confirmed by one of the approved methods described in Appendix 1. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The plug must extend from a minimum of 15 m below the completion or total depth, whichever is shallower, to a minimum of 15 m above the completion. If this plug is to be drilled out, the squeezed interval must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

Option 5–Setting a Cement Plug

A thermal cement plug must be set across the perforations or the single-zone open-hole section. The plug must extend a minimum of 15 m above the top of the formation and a minimum of 15 m below either the completed interval or the plug-back total depth, whichever is shallower. The location of the plug must be confirmed by one of the approved methods described in Appendix 1. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

5.3 Groundwater Protection

The EUB requires that all nonsaline groundwater be covered by cement. Approved groundwater isolation includes the identification and isolation of the base of usable groundwater from hydrocarbon formations below, as well as the identification and isolation of all formations of varying salinity. See *Statistical Series (ST)55: Alberta's Base of Groundwater Protection Information* for information on how to determine the groundwater protection depth for a well. The EUB will only consider industry requests to waive the requirement to cover nonsaline groundwater in specific situations. See Appendix 3 for guidelines on requesting a groundwater protection waiver.

If after conducting the following operations, all nonsaline groundwater is not covered with cement, the licensee must contact the Well Operations Section for further direction. At that time, a cement bond log and an open-hole log across the nonsaline groundwater(s) must be provided to determine what further operations may be required to ensure isolation of dissimilar nonsaline groundwater.

5.3.1 Remedial Cementing

There are two acceptable methods for remedial cementing to cover all nonsaline groundwater:

Option 1–Perforating, Milling, or Slotting Casing

Perforate, mill, or slot the casing a minimum of 15 m below the base of the nonsaline groundwater. Attempt to establish circulation to the surface with fresh water. (Note that acid must not be used to establish circulation.)

If the freshwater circulation is successful, pump the cement to surface. Once the cement has set, the plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

If the freshwater circulation is unsuccessful, attempt to establish a feed rate at which pressure can be applied without exceeding the formation fracture pressure.

- If a feed rate *can* be established, squeeze cement into the perforations (without exceeding the fracture pressure). Once the cement has set, the plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. Then, contact the Well Operations section for further direction.

- If a feed rate *cannot* be established, set a cement plug across the perforations or the open-hole section. A minimum of 15 m of cement is required above and below the perforated casing. The location of the plug must be confirmed by one of the approved methods described in Appendix 1. The plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. Contact the Well Operations Section for further direction.

Option 2–Performing a Cement Squeeze Between Two Sets of Perforations

A cement squeeze is conducted by perforating at two points in the well across the nonsaline groundwater. Attempt to establish circulation between the points with fresh water using a retainer. (Note that acid must not be used to establish circulation.) The retainer must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. Pump cement between the perforations. The cement top inside the casing must extend a minimum of 15 m above the upper perforations. Once the cement has set, it must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

5.3.2 Removing Casing and Setting a Cement Plug

If the casing is free at or below the base of all nonsaline groundwater, the licensee may cut and pull the casing. Casing removal schemes that meet the following requirements are **routine**. Any casing string other than the surface casing may be removed.

The intended cut point must be identified at or below the base of all nonsaline groundwater. A bridge plug must be set a minimum of 15 m below the intended cut point. Next, the plug must be pressure tested at a stabilized pressure of 7000 kPa for 10 minutes. The casing may then be cut and pulled. A cement plug must be set from the bridge plug to a minimum of 15 m above the surface casing shoe. If the casing is unsuccessfully severed, a cement plug of a minimum of 30 m must be placed across the intended cut point. The cement plug must be located and pressure tested at a stabilized pressure of 7000 kPa for 10 minutes.

5.4 Surface Abandonment

Surface abandonment is the cutting off of casing string(s) and the capping of a well. Surface abandonment must be reported via the DDS Well Licence Abandonment service within 30 days of completing the operation.

Surface equipment, cement pads, debris, and produced liquids associated with the well licence must be removed within 12 months of the cutting and capping operation. Record of the removal and cleanup activities must be retained by the licensee and may be requested in an audit.

5.4.1 Testing

Before beginning any routine or *approved* nonroutine surface abandonment operation, the licensee must perform certain required tests on the well. It is advisable to perform testing prior to beginning downhole abandonment operations to avoid having to re-enter the well to correct a wellbore problem.

Surface Casing Vent Flow (SCVF) Test

The licensee must conduct a *surface casing vent flow test* to determine if gas, liquid, or any combination of substances is escaping from the casing vent assembly. As required in *ID 2003-01*, a licensee must check all wells for a vent flow prior to surface abandonment. See Appendix 2 for recommended test procedures. If a vent flow is detected, the licensee must notify the EUB via the DDS Surface Casing Vent Flow/Gas Migration (SCVF/GM) service within 30 days of detection. All vent flows (serious and nonserious) must be addressed prior to well abandonment.

Gas Migration (GM) Test

The licensee must conduct a *gas migration test* in the required test area to determine if gas is detectable outside the outermost casing string. As required in *ID 2003-01*, a licensee must check all wells in the required test area for gas migration prior to surface abandonment (see Figure 13). Although not a requirement, the EUB believes all wells should be tested for gas migration prior to abandonment. See Appendix 2 for recommended test procedures. If a gas migration problem is detected, the licensee must notify the EUB via the DDS Surface Casing Vent Flow/Gas Migration (SCVF/GM) service within 30 days of detection.

Required Test Area
Townships 45-52, Ranges 1-9, W4M
Townships 53-62, Ranges 4-17, W4M

If gas migration is discovered *after* surface abandonment has been completed on a well, the licensee must notify the EUB via the DDS Surface Casing Vent Flow/Gas Migration (SCVF/GM) service within 30 days of detection. The licensee must re-enter and reabandon the well after requesting approval for a nonroutine abandonment.

5.4.2 Cutting and Capping

The licensee may not begin surface abandonment if any test result indicates a wellbore problem.

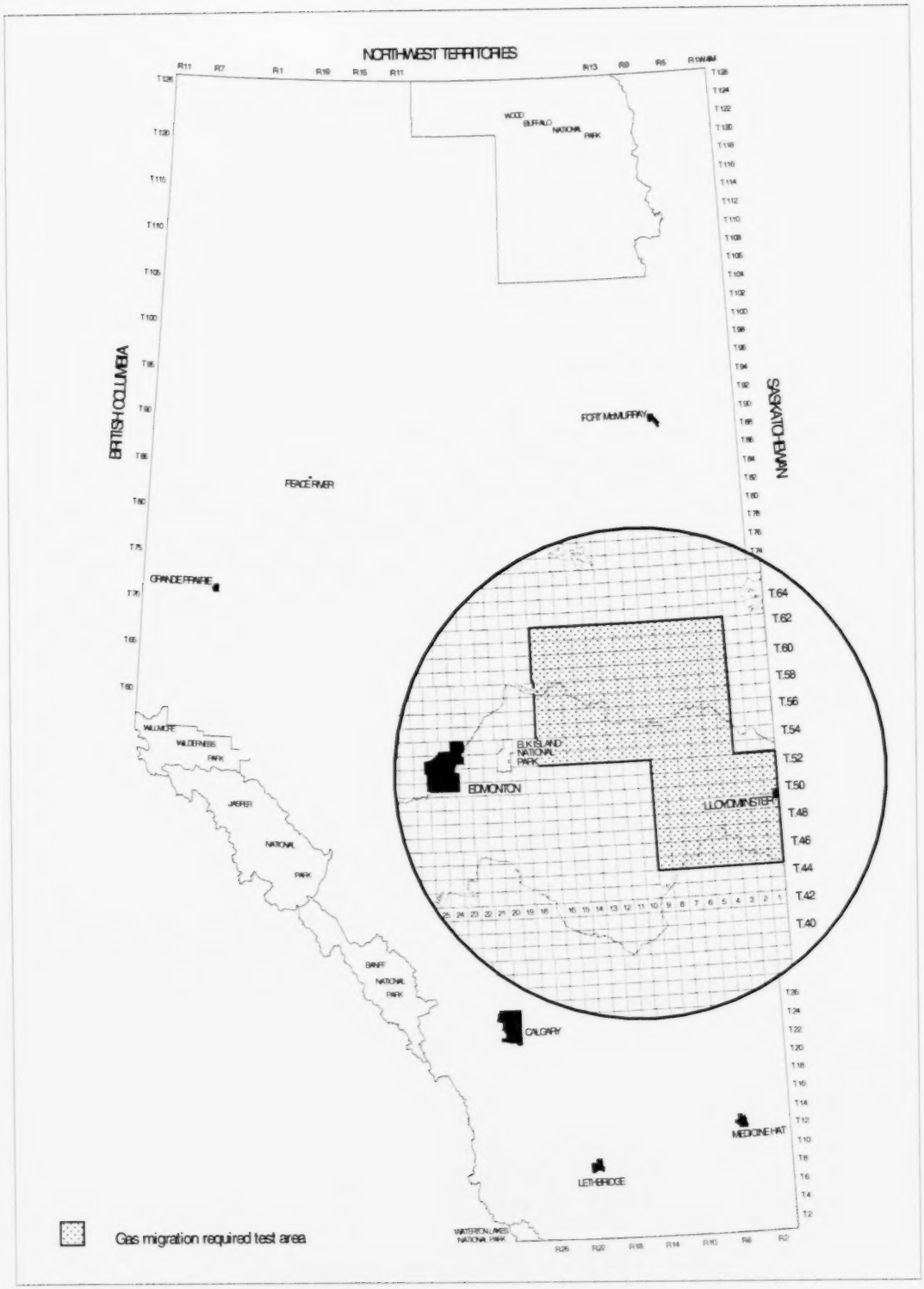


Figure 13. Gas migration required test area

Surface abandonment consists of cutting the casing string(s) off at a specific depth below the well's final contour elevation. The casing strings must be cut off a minimum of 2 m below final contour elevation if the well is

- in an area with special farming practices, such as deep tillage, drainage works, or peat lands, or
- within 15 km of urban development.

If the well is not located in an area with special farming practices or within 15 km of urban development, the casing strings must be cut off a minimum of 1 m below the final contour elevation.

All casing strings other than the surface casing must be plugged at surface with either

- a minimum 8 linear metre cement slurry on top of a wiper plug, or
- a steel plate welded across the casing string.

The surface casing must be sealed at surface with a steel plate welded across the surface casing (see Figure 14). The steel plate must be metallurgically compatible to the casing and welded according to industry standards to eliminate the possibility of creating corrosive cells that may occur when dissimilar materials are used. Record of the type of steel plate and welding procedure used must be retained by the licensee and may be requested in an audit.

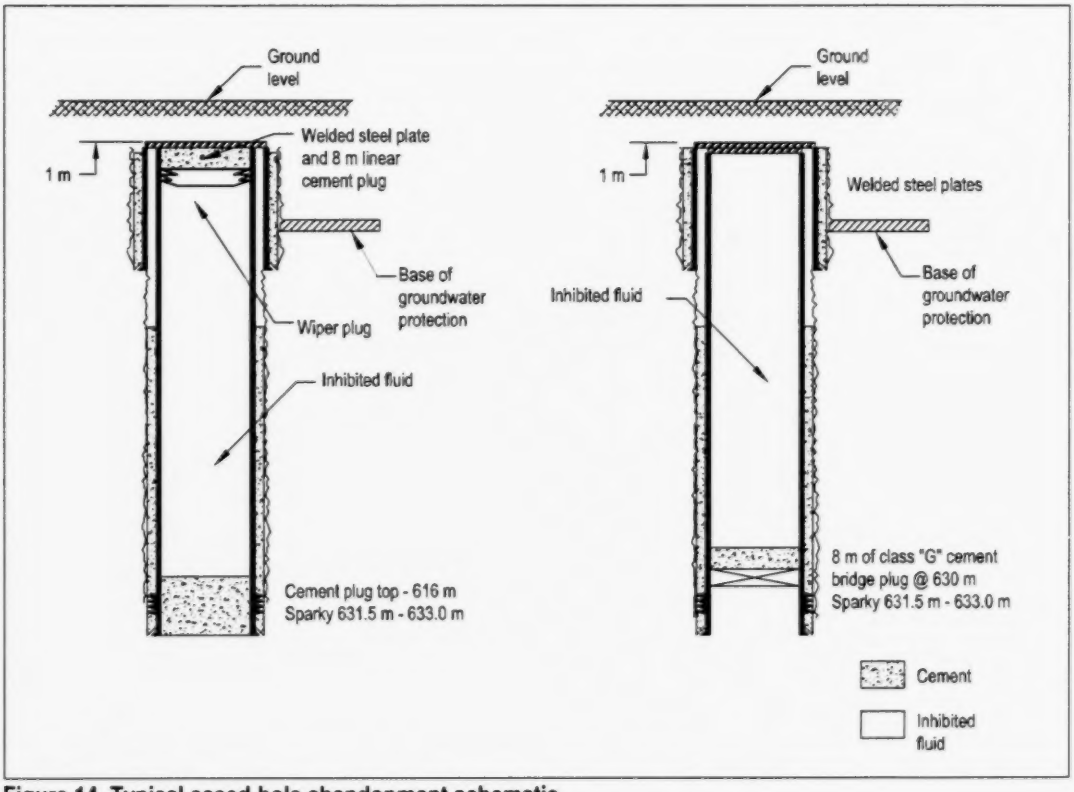


Figure 14. Typical cased-hole abandonment schematic

Appendix 1 Confirming the Location of Cement Plugs

There are four EUB-approved methods for confirming the location of plugs.

Method 1–Confirmation of Plug Location with Drill Pipe

This method uses a strap tally—measuring and counting joints of drill pipe—and subsequent tally adjustments to determine the drill pipe setting depth for each plug and the location of the plug top.

The location of the plug top must not be confirmed until 8 hours from the time the plug was run or a period of 4 hours provided that surface samples have set. The minimum force with which plugs must be located is 1800 decanewtons or string weight, whichever is less.

If the licensee are locating a plug top during a cased-hole abandonment operation, the plug must be tagged using tubing or coil tubing. The minimum force with which the plugs must be located is 1800 decanewton or string weight, whichever is less. Note that the use of slick line or wireline is *not* an approved plug top locating method.

The licensee must meet the following reporting requirements for this method. These details must be included in the tour reports:

- cement type, mass (tonnes), and slurry volume (in cubic metres) for each plug,
- drill pipe setting depth (strap tally and tally adjustments must be shown on the drilling tour reports to support the reported drill pipe setting depth),
- force (in decanewtons) with which the plug top was felt,
- plug top depth (strap tally and tally adjustments must be included to support the reported plug top location), and
- date and time that the location of each plug was confirmed.

A plug log is not produced for this method.

Method 2–Direct Density Plug Logging

This method uses a radioactive source and a detector run on wireline. Tool calibration must be performed at least once per job. The resulting log must show fluid density, fluid gradient, or cement percentage.

The difference between the cement density and the density of the drilling fluid must be at least 300 kilograms per cubic metre (kg/m^3) (or 2.9 kPa/m). A minimum of 25 m of plug must be logged to accurately determine the plug top. The position of the plug top is interpreted as a suitable intermediate point between drilling fluid and cement slurry density, commonly 1600 kg/m^3 (or 15.7 kPa/m).

A plug log must be produced for this method and must be submitted to the EUB Resource Information Section. A calibration time and results must be included on the log.

Method 3–Hydrostatic Pressure Plug Logging

This method uses a pressure transducer run on wireline. As the tool travels, the difference between pressure readings produces a fluid gradient, which may then be converted to fluid density. The tool must be run continuously and the tool must be calibrated in

accordance with Section 11.110 of the *Oil and Gas Conservation Regulations*. The resulting log must show fluid density, fluid gradient, or cement percentage.

The difference between the cement density and the density of the drilling fluid must be at least 300 kilograms per cubic metre (kg/m^3) (or 2.9 kPa/m). A minimum of 25 m of plug must be logged to accurately determine the plug top. The position of the plug top is interpreted as a suitable intermediate point between drilling fluid and cement slurry density, commonly 1600 kg/m^3 (or 15.7 kPa/m).

A plug log must be produced for this method and must be submitted to the EUB Resource Information Section. The serial number, range, and date of last calibration of the gauges must be shown on the plug log.

Method 4–Radioactive Tracer Logging

This method uses a radioactive tracer introduced into the lead slurry. The location of the plug top is confirmed by detection of the tracer with a gamma ray logging tool. Since the radioactive logging method is locating the radioactive tracer, adequate precautions must be taken to properly mix the tracer with the cement to prevent channelling of the cement during pumping and displacement. The EUB recommends that spacer fluid be used before the cement to prevent channelling. The resulting log must show the location of the tracer, which is then interpreted as the plug top.

A plug log must be produced for this method and must be submitted to the EUB Resource Information Section.

Plug Log Submission Requirements

Plug logs generated for Methods 2, 3, and 4 must be submitted within 30 days of completing downhole abandonment operations. It is the licensee's responsibility to ensure that all of the following reporting requirements for open-hole abandonments are met. Although some of the information required is obtained from third parties on the well site (e.g., the slurry volume), the licensee must ensure that the information is accurate.

The requirements for plug logs are as follows:

- A gamma ray or other type of suitable log that can be correlated to the open-hole log suite must be run for depth-control purposes. The base gamma ray log must be traced onto the plug log and depth corrections made as necessary, or the licensee must include remarks on the plug log for all gamma ray deflections that were visually correlated, as well as any depth corrections made.

- A collar locator must be run in conjunction with tally adjustments to determine the drill pipe setting depth for each plug. In the absence of a collar locator, strap tally and tally adjustments must be used.

- The drill pipe must be pulled above the top of the plug prior to confirming its location with a logging tool.

- If the plug logging method fails to clearly indicate the plug top, the licensee must confirm the location of the plug top with drill pipe according to Method 1.

The licensee must submit the following information with the plug log:

- mud density and bit size,
- interval to be cemented,
- drill pipe setting depth (strap tally and adjustments used in conjunction with the collar locator must be included to support the drill pipe setting depth),
- mass in tonnes and volume in cubic metres of cement that was run during placement of the plug (this includes the calculated volume plus any excess run),
- type/class of cement used, including any additives and the average slurry density,
- volume of displacement fluid used,
- plug placement time and logging time,
- interval logged,
- depth at which the cement top was logged,
- quality of cement samples (this is a visual analysis usually conducted by the cementing company; the analysis consists of time required for samples to set at surface), and
- a trace of the base correlation log must be shown on the plug log or remarks for all gamma ray deflections that were visually correlated and any depth corrections made.

Appendix 2 Testing for Surface Casing Vent Flow and Gas Migration

Section 6.100 of the *Oil and Gas Conservation Regulations* specifies that the annulus between the second casing string and the surface casing of a completed well must be left open to atmosphere. The licensee must test the surface casing for a vent flow or gas migration in the manner set out below. If a surface casing vent flow or gas migration problem is detected, the licensee must report and repair it as set out below. See *ID 2003-01: Isolation Packer, Surface Casing Vent Flow/Gas Migration, Casing Failure Testing, Reporting and Repair Requirements.*

Surface Casing Vent Flow Testing

Use either a positive displacement gas meter or an orifice well tester to measure vented gas volumes. Equipment selection must be based on previous observations indicating what flow rate and pressure range can be expected. A positive displacement meter will be necessary to measure low volumes accurately. An orifice well tester (with proper orifice plate) may provide satisfactory measurements if 24-hour SI pressure is 200 kPa or greater and builds quickly. Install and use the equipment according to manufacturer's instructions, keeping in mind the following:

- Do not exceed the pressure/volume range of the equipment.
- Ensure that the fittings, wellhead, etc., are not leaking.
- Leave casing vents open when equipment is removed, unless specifically directed by the EUB to close them.

Required Equipment

1) A container of water (from 500 millilitres to 1 litre)
2) Pipe fittings, small hose (minimum 6 mm), or other equipment necessary to direct gas flow from vent downward into the water container*

Testing Procedures

1) Ensure that there are no gas leaks at fittings and welds.
2) Ensure that all valves in the vent line are open.
3) If necessary, connect test fittings to vent so gas flow can be directed into the container of water.
4) Immerse vent or hose a maximum of 2.5 cm (1 inch) below the water surface.
5) Observe for 10 minutes. Note any gas flow (i.e., bubbles), which must be recorded as a positive vent flow.
6) Record observations.

* No fittings or extra equipment will be required for most surface casing vents completed in the form of an inverted "J" with the open end facing downward.

A vent flow is considered serious if there is a stabilized gas flow equal to or greater than 300 m^3/d and/or a stabilized shut-in casing pressure greater than or equal to the maximum allowable shut-in pressure. To determine the maximum shut-in casing pressure for a well, use the following method.

Required Equipment

1) Pressure gauge or single pen static pressure recorder with 24-hour chart

2) Pressure relief valve calibrated to release at a pressure equal to 11 kPa/m x length of surface casing setting depth (m)

Testing Procedures

1) Install pressure recorder or pressure gauge and pressure relief valve.

2) Ensure that there are no gas leaks at fittings and welds.

3) If a chart is used, note the chart reading 24 hours later.
   - If pressure has not stabilized, it will be necessary to change the recorder on to cover a longer time period in order to achieve a maximum shut-in pressure. Repeat steps 1 and 2.
   - If chart pressure reached the maximum pressure relief valve setting, record result.
   - If chart pressure stabilized and is below pressure relief valve setting, record result.

If a pressure gauge is used, monitor the readings to determine when a stabilized maximum pressure is obtained and record this value.
- If gauge pressure reaches the maximum pressure relief valve setting, record result.
- Remove equipment and leave casing venting.

Gas Migration Testing

In order to ensure that testing is done using standardized procedures, the Lloydminster Area Operations Group Gas Migration Team (LAOGMT) drafted the following testing procedures. The EUB endorses these procedures and recommends they be used provincewide. The licensee is required to follow the ground disturbance requirements as described in the *Pipeline Act* and *Regulation*.

Testing must be done only in the frost-free months and periods immediately after a rainfall must be avoided. If less than full-scale readings are obtained, the soil horizon must be examined to ensure that readings are not the result of contaminated soils due to spills of diesel fuel, solvents, oil, etc. If contaminated soils are suspected, the soil must be excavated and removed. Retesting is then required. Instrumentation must be calibrated regularly and checked daily when in use.

Select sample testing points as follows:

- two within 30 cm of wellbore on opposite sides, and
- at 2 m intervals outward from the wellbore every 90° (a cross with the wellbore at centre) to a distance of 6 m, and
- at any points within 75 m of wellbore where there is apparent vegetation stress.

Required Equipment

1) Bar or auger (64 mm or less in diameter) capable of penetrating a minimum of 50 cm deep

2) Calibrated explosion meter or other instrument capable of detecting hydrocarbon at 1 per cent lower explosive limit (LEL)

3) Equipment or material to seal hole at surface while soil gases are being evacuated from the soil through the instrument

Testing Procedures

1) Perform instrument check (calibration, voltage, zero, etc.).

2) Insert auger or make a bar hole a minimum of 50 cm deep.

3) Isolate the hole from atmospheric contaminations.

4) Insert hose, wand, or other equipment a minimum of 30 cm into hole, maintaining a seal at surface to prevent atmospheric gas and soil gas mixing.

5) Withdraw soil gas sample. The volume, rate, etc., will depend on the instrumentation being used. Ensure that a sufficient sample is removed to purge lines and instrumentation.

6) Record observations.

7) Purge instrument and lines.

Appendix 3 Requesting a Groundwater Protection Waiver

The EUB requires that all nonsaline groundwater be covered by cement. In specific situations, the EUB will consider industry requests to waive the requirement to cover nonsaline groundwater for cased-hole wells that do not have any wellbore problems. Abandonment operations for which a groundwater waiver is requested are nonroutine. A written assessment containing the required information must be completed by the licensee and submitted to the EUB Well Operations Section before a nonroutine abandonment request is submitted via the DDS Nonroutine Well Abandonment service. Nonroutine abandonment requests for waivers that are submitted before the assessment is received will be denied. A request for a groundwater protection waiver must be approved by the EUB prior to beginning any work.

Waivers are only considered for three types of situations:

Situation 1–Absence of Porosity Above Cement Top

The EUB will consider requests to waive the requirement to cover all nonsaline groundwater if a licensee can conclusively prove that there is no porosity (defined as less than 3 per cent in sandstone) between the surface casing shoe and the cement top. The lack of porosity indicates there is no nonsaline groundwater within this zone.

The written assessment must include

- the surface casing depth,
- the production casing cement top(s) and method of identification, and
- the base of all nonsaline groundwater, the source of data, and confirmation by a qualified log analyst of the absence of porous zones between the cement top and the base of all nonsaline groundwater. The evaluation must be based on all available data, including that from offsetting wells. As porosity logs may be unreliable at shallow depths, the licensee must rely heavily on the gamma ray log and samples for this analysis. The evidence provided in the written assessment must prove that there are no porous zones between the cement top and the base of all nonsaline groundwater in the well to be abandoned. Gamma ray logs and actual samples must be used to prepare the evidence.

Situation 2–Failure of Remedial Cementing in the Area

The EUB will consider requests to waive the requirement to cover all nonsaline groundwater if the licensee can prove that remedial cementing of wells in the area has been repeatedly unsuccessful. Application areas must be no larger than two townships (72 square miles or 185 square kilometres) and contain no more than 100 wells.

The written assessment must include

- a review and interpretation of Alberta Environment water well data for all water wells within the surrounding eight townships (i.e., nine-township area total) that were drilled deeper than the surface casing depth of the well to be abandoned, and

- evidence from unsuccessful remedial cementing from at least five wells or 10 per cent of wells to be abandoned in the application area, whichever is more. This evidence must show that remedial cementing efforts to cover all nonsaline groundwater resulted in the total inability to obtain a feed rate (i.e., a feed rate of 0.0 m^3 per minute) without acidizing the formation or exceeding fracture pressures. All wells in which a feed rate was attempted must be evenly distributed throughout the area of application. Feed rate data must be from within the past five years. All wells attempted and applied for must have been completed in a similar manner. For areas with diverse well ownership, companies may obtain necessary data from EUB records on daily tour reports.

Situation 3–Absence of Deleterious Crossflow

The EUB will consider requests to waive the requirement to cover all nonsaline groundwater if a licensee can produce potentiometric mapping to demonstrate that there is no deleterious crossflow potential between the lowest exposed nonsaline groundwater and the next stratigraphically lower saline aquifer.

The written assessment must include

- a review and interpretation of Alberta Environment water well data for all water wells within the surrounding eight townships (i.e., nine-township area total) that were drilled deeper than the surface casing depth of the well to be abandoned,

- geologic and hydrochemical interpretation and description of all aquifers (these may be available in the information sources noted above), and

- a comparison of the potentiometric surface of the lowest nonsaline groundwater aquifer and that in the next lowest saline aquifer, including a statement that there is no positive flow potential between these two aquifers.